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ADVANCED TURBULENT FLOW COMPUTATIONS

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PREFACE

This book collects the lecture notes concerning the IUTAM School on Advanced Turbulent Flow Computations held at CISM in Udine on September 7-11, 1998. The course was intended for scientists, engineers and post-graduate students interested in the application of advanced numerical techniques for simulating turbulent flows. The topic comprises two closely connected main subjects: modelling and computation.

The former subject is concerned with the fundamental and practical aspects of fluid- dynamic modelling of turbulent flows. With the availability of high-performance computers different levels of approximation can be employed in the modelling process. The approximations being used at present range from asymptotic theories, for the construction of wall functions for example, to hierarchies of closure assumptions for the Reynolds stresses, when the Reynolds-Averaged-Navier-Stokes equations or simplifications thereof are being used, to large-eddy simulations, requiring only the turbulent subgrid quantities to be modelled, and to direct simulations, in which the flow is attempted to be described without introducing any approximations.

The latter subject is concerned with the development of efficient and yet extremely accurate numerical solutions to the conservation equations. The numerical solutions involve, in general, the generation of a mesh, offering sufficient resolution of the flow to be simulated, the discretization of the conservation equations with improved high-order techniques, and the solution of the resulting linear or non-linear algebraic equations. The constraint for time-efficiency is dictated by the usually large number of mesh points necessary to simulate complex turbulent flow.

The first Chapter, by R. Peyret, is a general presentation of high-order approximation methods for application to Computational Fluid Dynamics by successively considering space and time discretization techniques.

The fundamentals of Large Eddy Simulation (LES) are developed by M. Germano in Chapter 2, with a special emphasis on the dynamic modelling procedure. A theoretical presentation of the LES approach is presented, showing, in particular, how it is located between Direct Numerical Simulation and Reynolds-Averaged-Navier-Stokes solutions.

In Chapter 3, P. Moin discusses some numerical issues of LES for complex flows and, especially, on high-order spatial approximation by B-splines, sensitivity of the solutions to inflow and outflow boundary conditions, and the influence of filtering. Examples of applications show, in particular, that the LES approach is well suited to numerical studies in Aeroacoustics.

Chapter 4, by M. Meinke and E. Krause, is devoted to a presentation of numerical solutions of compressible flow equations within the LES approach. In particular, a comprehensive comparison is done between high-order compact and second-order finite-difference solutions. Examples of applications to jet flows and various internal flows illustrate the presentation.

Chapter 5, by M. Leschziner, constitutes a comprehensive contribution to the modelling and the computation of complex turbulent flows of engineering nature, placing emphasis on second-moment closure and non-linear eddy-viscosity modelling. A large number of examples, concerning incompressible and compressible flows, are presented in order to assess the performance of the models.

Finally, in Chapter 6, V. Couaillier discusses the calculation of compressible flows using Reynolds-Averaged-Navier-Stokes equations. A detailed analysis of the numerical schemes well adapted to computation in complex geometry is presented. Applications to three-dimensional flows (transonic channel with a swept bump and wing-body-pylon-nacelle) illustrate the performance of the methods.

Roger Peyret
Egon Krause

CONTENTS